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Association of adherence to the dietary approach to stop hypertension and Mediterranean diets with blood pressure in a non-hypertensive population: Results from Isfahan Salt Study (ISS)

Mehran Rahimlou [a], Narges Grau [b], Nasrin Banaie -Jahromi [a], Marzieh Taheri [c], Alireza Khosravi [d], Yiannis Mavrommatis [e], Noushin Mohammadifard [b,*]

[a] *Department of Nutrition, Faculty of Medicine, Zanjan University of Medical Sciences, Zanjan, Iran*
[b] *Isfahan Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran*
[c] *Interventional Cardiology Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran*
[d] *Hypertension Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran*
[e] *Faculty of Sport Health and Applied Science, St Mary's University Twickenham, TW14SX, UK*

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KEYWORDS
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Abstract *Background and aims:* Hypertension is among the major risk factors for cardiovascular events in the Iranian population. This cross-sectional study was designed to examine the association of adherence to the dietary approaches to stop hypertension (DASH) and Mediterranean (MED) dietary patterns with the distribution of blood pressure and pre-hypertension prevalence.
Methods and results: This cross-sectional study was carried out in 1363 non-hypertensive adults. Adherence to the DASH and MED diets was calculated using a semi-quantitative food frequency questionnaire (FFQ). Hypertension was measured by the standard method. Multiple logistic regression was applied to obtain the odds ratio of pre-hypertension in the tertiles of MED and DASH dietary patterns. Compared to the lowest, participants with the highest adherence to the DASH dietary pattern had significantly lower systolic blood pressure (SBP) (111.3 ± 11.8 vs. 112.8 ± 12.5; P = 0.010) and diastolic blood pressure (DBP) (70.7 ± 9.2 vs. 71.8 ± 9.8; 0.042). There was no significant difference in the mean SBP and DBP among the participants across tertiles of MED or diet adherence. Higher scores of the DASH and MED diets were inversely associated with lower SBP after adjustment for all potential confounders (OR = −0.04, 95% CI = −0.29, −0.01, P = 0.039) and (OR = −0.04, 95% CI = −0.72, −0.02, P = 0.044), respectively. Also, DASH and MED dietary patterns was associated with reduced OR of pre-hypertension occurrence by 13% (OR: 0.87; 95% CI: 0.70–0.98; P for trend = 0.042) and 16% ([OR: 0.84; 95% CI: 0.69–0.97; P trend = 0.035), respectively.
Conclusion: Adherence to the DASH and MED diets was inversely associated with the odds for pre-hypertension and SBP.

Abbreviations: BP, blood pressure; CVD, cardiovascular disease; DASH, dietary approaches to stop hypertension; IPAQ, International Physical Activity Questionnaire; IFCP, Iranian Food Consumption Program; EPIC, European Prospective Investigation into Cancer and Nutrition; HDL-C, high-density lipoprotein cholesterol; FBG, fasting blood glucose; FFQ, food frequency questionnaire; MED, Mediterranean; SBP, systolic blood pressure; MET, metabolic equivalent of task; MUFAs, monounsaturated fatty acids; LDL-C, low-density lipoprotein cholesterol; NCEP-ATP III, National Cholesterol Education Panel Adult Treatment Panel III; SFA, saturated fatty acids; TC, total cholesterol.

* Corresponding author. Isfahan Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail address: nmohammadifard@gmail.com (N. Mohammadifard).

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Introduction

High blood pressure (BP) is one of the major modifiable risk factors for cardiovascular disease (CVD) and all-cause mortality [1]. Based on reports from the World Health Organization (WHO), hypertension accounts for approximately 9.5 million global deaths each year [2]. It has been estimated that by 2030 hypertensive diseases will be responsible for more than 25% of deaths in both developed and developing countries [3]. Only in 2017, nearly 20% of the Iranian adult population suffered from hypertension [4]. The risk for CVD is 3.3 times higher among individuals with hypertension compared to those with normal BP [5]. Among the underlying causes in the development of hypertension are genetic factors, obesity, unhealthy diet, physical inactivity, and stressful lifestyle [6]. The adoption of the Western dietary pattern rich in red meat and fats, sugary drinks, and processed food is associated with a higher risk of hypertension [7]. In Iran, there has been a remarkable nutrition transition toward the Western diet in recent years, which may explain in part the high prevalence of hypertension in the Iranian population [7,8]. Adherence to healthy dietary patterns like the dietary approaches to stop hypertension (DASH) diet and the Mediterranean (MED) diet can have protective effects against a number of chronic diseases, including hypertension [9,10]. Several studies have shown that following the DASH diet can lower systolic blood pressure (SBP) [11,12]; however, the effects on diastolic blood pressure (DBP) have been conflicting [13,14]. Moreover, it appears that the DASH diet has a substantial effect on BP only among hypertensive individuals [15,16], not among the participants with normotensive conditions [17,18]. Similar and contradictory results have been reported for the MED diet [19,20].

The findings from a prospective cohort study showed that adherence to the DASH-style diet was associated with a lower risk of hypertension [21], whereas the Framingham Offspring study did not show any significant association between the DASH diet and BP [22]. Studies performed by the US National Institute of Health and European scientific centers have reported that adherence to the DASH and MED diet is effective in clinically relevant reductions in BP, specifically SBP, in both hypertensive and normotensive individuals [23,24]. Also, a recent systematic review and meta-analysis showed a significant positive association between adherence to the MED diet and BP reduction [25]. The majority of the data related to this topic comes from studies performed in Western communities, and little evidence is available from the Middle East where the prevalence of hypertension is relatively high [4]. Due to the high prevalence of hypertension and subsequent CVD morbidity and mortality among Iranians [4], evaluating the association of healthy dietary patterns with BP can provide valuable evidence for primary prevention of hypertension. Therefore, this cross-sectional study was performed to assess the potential link between adherence to the DASH and MED diets with BP in a non-hypertensive population in Iran.

Methods

Study population

This cross-sectional study used data from the Isfahan Salt Study (ISS), which was conducted on adult participants (>18 years) in Isfahan city as a representative population of Iranian adults, in 2013–2014. Isfahan is located in the center of Iran with the same age and sex distribution and socioeconomic status to the whole country. The details of ISS design have been published elsewhere [26]. A total of 1363 individuals were selected using the stratified multi-stage cluster random sampling method. For stratification, Isfahan city was divided into two starta including Isfahan health center 1 and 2, with estimated populations of 779,847 and 1,006,276, respectively. Random clusters of 12 and 15 were chosen in health centers No 1 and No 2, respectively. An equal number of households was drawn from each cluster, followed by the selection of one eligible adult participant from each household. Participants without a history of hypertension, CVD, diabetes mellitus, or other chronic disorders were included in the study. This study was approved by the Research Council of Isfahan Cardiovascular Research Institute (ICRI) and a WHO collaborating center. Written consent forms were obtained from all the participants.

Data collection

At recruitment, participant characteristics including age, sex, marital status, education, and income status were collected by trained health professionals. The medical and nutritional supplements taking a history of all subjects were obtained. Anthropometric measurements were done by a trained researcher at baseline and at the end of the study. Height was measured without shoes to the nearest 0.5 cm, and weight was measured without shoes and with light clothing with a precision of 0.1 kg using a Seca scale. The waist circumference (WC) was measured at the horizontal plane midway between the lowest rib and the upper border of the iliac crest at the end of normal inspiration/expiration. Body mass index (BMI) was calculated as weight in kilograms divided by square of height in meters (kg/m^2). BP was measured manually by a trained operator using a mercury sphygmomanometer according to standard protocol [27], twice from right and left arms in sitting position after 5 min of rest. We kept the BP measurement environment silent to hear Korotkoff sound. The first Korotkoff sound was recorded as the SBP, and the disappearance of the sounds (V phase) was considered the DBP. The mean of the two BP readings on the arm with higher BP was used in the analyses. Physical activity was evaluated by the International Physical Activity Questionnaire (IPAQ) [28]. IPAQ scores were reported as metabolic equivalent of task (MET) minutes per week [29].

A 10 ml fasting blood sample was collected from each participant. Serum concentrations of high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-

C), and fasting blood glucose (FBG) were evaluated using commercial kits (Pars Azmoon Co., Tehran, Iran). Dyslipidemia was defined according to the National Cholesterol Education Panel Adult Treatment Panel III (NCEP-ATP III) [30]. Diabetes was defined based on the American Diabetes Association Criteria [31,32]. Pre-hypertension was defined as SBP of 120–139 mmHg or DBP of 80–89 mmHg [33].

Dietary assessment

Dietary intake was assessed by a validated 136-item, semi-quantitative food frequency questionnaire (FFQ) [34]. The FFQ questionnaire was administered by a nutritionist and consisted of a list of foods with a standard serving size. Participants were asked about their usual frequency of food intake during the past year. Response categories ranged from never or rarely (less than 1 per month), 1–3 per month, 1 per week, 2–4 per week, 5–6 per week, 1 per day, 2–3 per day, 4–5 per day, and 6 or more per day. The reported portion sizes were converted to grams/day for each food item. Dietary data were entered into the Iranian Food Consumption Program (IFCP), designed by ICRC [35,36]. The IFCP calculated nutrient intake and food group servings for all consumed foods. Then, adherence to MED and DASH diets was examined by calculating their scores. After the dietary evaluation, all of the participants received nutritional guidance with information on a healthy diet.

Mediterranean diet score

The MED scores were estimated based on the methods introduced by Trichopoulou et al. [37]. A value of 1 was assigned to people whose consumption of fruits and vegetables, whole grains, legumes, nuts, fish, and monounsaturated fatty acids (MUFAs) to saturated fatty acids (SFAs) ratio was equal or greater than age-specific median, and zero to the others. Meat (red and processed meats, poultry) and dairy products were scored on a reverse scale because they are not typical of a MED. The scores were subsequently summed up to construct the overall adherence to the MED diet score, ranging from 0 to 8. Individuals with the highest MED score were more likely to follow the MED diet.

Dietary approach to stop hypertension diet score

The DASH scores were determined based on the protocol published by Fung and colleagues [38]. According to the original study, the DASH diet focuses on eight food components. Each food component is categorized in quintiles. For components such as fruits, vegetables, whole grains, nuts, legumes, liquid oil (olive oil and unhydrogenated vegetable oil), and low-fat dairy products, individuals in the highest quintile received a score of 5, those in the second-highest quintile received a score of 4, and so on. For other components including meat and meat products, sugar-sweetened beverages, fat (hydrogenated oil, animal fat, and butter), and sodium, the scoring was reversed. Individuals in the highest quintile received a minimum score of 1, while those in the lowest quintile received a maximum score of 5. The scores were then summed up and the overall score ranged from 8 to 40, with 8 reflecting no adherence and 40 reflecting perfect adherences to the DASH diet.

Statistical analysis

Dietary intake was adjusted for energy intake using the residual method. Participants were categorized in tertiles according to the overall MED and DASH scores. Individuals' characteristics were evaluated across the tertiles of MED and DASH dietary patterns, using chi-square for categorical variables and one-way analysis of variance (ANOVA) for continuous variables. The linear regression model was used, and all independent variables were entered at once to determine the association between the tertiles of MED and DASH dietary patterns with means of SBP and DBP.

Multiple logistic regression was applied to obtain the odds ratio of pre-hypertension in the tertiles of MED and DASH dietary patterns. Statistical analyses were performed using SPSS v.23.0 (IBM Corp., Armonk, NY, USA). The significance level was set at $P < 0.05$.

Results

Baseline characteristics of the 1363 study participants are shown in Table 1. The mean age of participants was 37.9 ± 10.6, consisted of 51% women. In this study, age was positively associated ($P = 0.002$) with adherence to the DASH diet, while women were more likely to adhere to both DASH ($P < 0.001$) and MED ($P = 0.012$) diets. Individuals with higher educational and income levels also tended to have a higher adherence to both DASH ($P = 0.009$ and $P < 0001$, respectively) and MED ($P = 0.043$ and $P = 0.028$, respectively) diets. There was no significant association between physical activity and metabolic factors (e.g., serum lipids and glucose levels) with adherence to either MED or DASH dietary patterns (Table 1).

Table 2 presents the participants' dietary intakes across the tertiles of MED and DASH scores. Individuals in the highest tertile of DASH diet had a significantly lower intake of total energy and fat, SFA, MUFA, PUFA, and cholesterol, but higher carbohydrate and protein intake compared with those in the first tertile ($P < 0.001$). In terms of the MED diet, individuals within the highest tertile tended to consume more total energy ($P < 0.001$), protein ($P = 0.003$), MUFA and PUFA and lower intake of cholesterol (all $P < 0.001$) were observed among those in the top tertile of MED diet. Those with higher adherence to DASH and MED diets had a significantly higher intake of fiber, magnesium, potassium, and calcium (all $P < 0.001$). However, higher adherence to DASH diet was associated with lower intake of sodium (0.001).

As shown in Fig. 1, higher adherence to the DASH dietary pattern was associated with lower SBP

Table 1 Characteristics of adherence among tertiles of adherence to dietary patterns.

Variables	DASH diet				MED diet			
	Tertile 1 N = 407	Tertile 2 N = 476	Tertile 3 N = 493	P for trend	Tertile 1 N = 596	Tertile 2 N = 356	Tertile 3 N = 424	P for trend
Female n (%)	172 (42)	222 (47)	306 (62)[1,2]	<0.001	330 (56)	170 (48)[1]	200 (47)[1]	0.012
Age (y)	36.7 ± 11.3	37.8 ± 10.3	39.1 ± 10.2	0.002	38.4 ± 10.4	37.5 ± 11.1	37.6 ± 10.4	0.232
BMI (kg/m^2)	26.4 ± 4.3	26.56 ± 4.2	26.7 ± 4.4	0.432	26.5 ± 4.3	26.60 ± 4.4	26.4 ± 4.3	0.675
WC (cm)	90.8 ± 11.2	91.40 ± 11.3	91.4 ± 11.6	0.261	90.7 ± 11.1	91.6 ± 11.8	91.2 ± 11.5	0.290
Illiterate and primary education n (%)	67 (17)	66 (14)	50 (10)	0.009	87 (15)	40 (11)	56 (13)	0.043
Income (less than 500US$)	73 (18)	68 (14)	47 (9)	<0.001	89 (15)	35 (10)	52 (12)	0.028
Physical activity (METS min/wk)	132.8 ± 140	134 ± 118.8	128.8 ± 102	0.126	126.8 ± 126.6	135.7 ± 121.5	131.0 ± 113.5	0.073
TG (mg/dL)	136 ± 83	140 ± 83.4	138.2 ± 71.6	0.326	136.7 ± 83.0	140 ± 74.2	138.4 ± 77.8	0.426
HDL-C (mg/dL)	47.0 ± 11.2	46.8 ± 11.1	47.3 ± 10.4	0.586	47.5 ± 10.3	46.3 ± 10.4	47.2 ± 12.0	0.240
LDL-C (mg/dL)	104.0 + 26.8	106.0 ± 30	102.4 ± 26.8	0.323	104.3 ± 27.4	103.9 ± 27.0	104.7 ± 28.8	0.971
TC (mg/dL)	182.7 ± 37.4	189.02 ± 41.4	188.1 ± 36.8	0.054	188.6 ± 39.6	185.3 ± 36.6	185.8 ± 39.1	0.716
FBG (mg/dL)	94.2 ± 14.5	94.0 ± 19.8	94.3 ± 18.5	0.702	94.6 ± 20.4	93.7 ± 17.2	94.1 ± 14.7	0.677

DASH: Dietary approach to stop hypertension MED: Mediterranean; BMI: Body mass index; WC; Waist circumference; TC: Total cholesterol; TG: Triglyceride; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; FBG: Fasting blood glucose.
1: The p value was significant (<0.05) in comparison with tertile 1.
2: The p value was significant (<0.05) in comparison with tertile 2.

(111.3 ± 11.8 mmHg vs. 112.8 ± 12.5 mmHg, P for trend = 0.010) and DBP (70.7 ± 9.2 mmHg vs. 71.8 ± 9.8, P for trend = 0.042). However, participants in the higher tertile of MED diet had no significant difference in the mean amount of SBP and DBP compared to the subjects in the lower MED diet tertile (112.0 ± 12.3 mmHg vs. 112.4 ± 11.8, P for trend = 0.503 for SBP and 71.7 ± 9.8 mmHg vs. 71.2 ± 9.4 mmHg, P trend = 0.431 for DBP).

Table 3 shows the linear relationship of DASH and MED scores and SBP. Increasing both DASH [−0.04 (−0.29, −0.01); P = 0.039] and MED [−0.04 (−0.72, −0.02); P = 0.044] scores were inversely associated with SBP after adjustment for all potential confounders. However, there was no significant association between the score of both dietary patterns and DBP.

Table 4 reports the multivariable-adjusted odds ratios and 95% confidence intervals (ORs; 95% CI) for pre-

Table 2 Dietary intakes of participants across tertiles of dietary patterns.

Nutrient intake	DASH diet Tertile 1 N = 407	Tertile 2 N = 476	Tertile 3 N = 493	P for trend	MED diet Tertile 1 N = 596	Tertile 2 N = 356	Tertile 3 N = 424	P for trend
Energy (kcal/day)	2123.3 ± 577.0	2059.3 ± 623.5	1996.9 ± 554.3	0.003	1934.5 ± 542.8	2075.7 ± 580.1	2209.9 ± 616.6	<0.001
Carbohydrate (% of energy)	58.4 ± 6.0	60.2 ± 6.9	60.8 ± 6.5	<0.001	59.7 ± 6.9	60.4 ± 7.1	59.81 ± 6.6	0.364
Protein (% of energy)	14.4 ± 2.5	15.0 ± 2.8	15.4 ± 2.7	<0.001	14.6 ± 2.6	14.6 ± 2.6	14.8 ± 2.8	0.003
Fat (% of energy)	30.3 ± 6.2	28.2 ± 6.1	27.6 ± 5.8	<0.001	28.4 ± 6.1	28.5 ± 6.2	30.0 ± 6.0	0.315
SFA (g/day)	30.6 ± 11.3	27.7 ± 11.0	25.1 ± 9.5	<0.001	27.0 ± 10.5	27.7 ± 10.6	28.3 ± 11.2	0.213
MUFA (g/day)	23.3 ± 8.3	21.6 ± 8.5	20.5 ± 8.2	<0.001	19.9 ± 7.4	22.0 ± 8.3	24.0 ± 9.3	<0.001
PUFA (g/day)	15.7 ± 7.3	14.5 ± 6.7	14.2 ± 6.8	<0.001	13.0 ± 6.0	15.0 ± 6.9	17.0 ± 7.7	<0.001
Cholesterol (mg/day)	307.3 ± 1.1	280.7 ± 1.0	243.6 ± 0.8	<0.001	288.4 ± 1.1	273.2 ± 0.9	267.2 ± 1.0	<0.001
Fiber (g/day)	15.6 ± 0.8	18.0 ± 0.8	20.5 ± 0.92	<0.001	15.2 ± 0.8	18.3 ± 0.8	22.4 ± 1.0	<0.001
Na (mg/day)	4607.0 ± 1399.6	4522.6 ± 1343.0	4276.3 ± 1300.8	0.001	4419.3 ± 1346.5	4502.3 ± 1350.0	4481.0 ± 1361.7	0.610
Mg (mg/day)	282.1 ± 1.0	300.4 ± 0.8	331.9 ± 1.1	<0.001	262.0 ± 0.7	321.2 ± 1.4	355.9 ± 0.9	<0.001
K (mg/day)	2575.3 ± 848.2	2826.3 ± 1011.1	3169.8 ± 940.0	<0.001	2559.7 ± 807.2	2875.7 ± 973.6	3318.1 ± 1003.8	<0.001
Ca (mg/day)	730.0 ± 1.0	750.7 ± 1.0	791.4 ± 0.9	<0.001	750.0 ± 1.0	751.7 ± 1.0	777.0 ± 1.0	<0.001

DASH: Dietary approach to stop hypertension; MED: Mediterranean; SFA: Saturated fatty acid; MUFA: Monounsaturated fatty acid; PUFA: Polyunsaturated fatty acid; Na: Sodium; Mg: Magnesium; K: Potassium; Ca: Calcium.

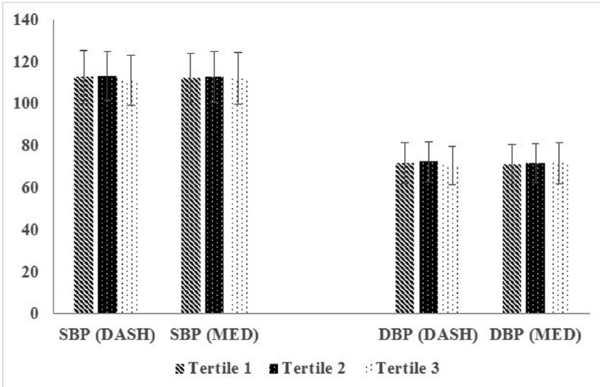

Figure 1 Mean blood pressure according to tertile of dietary patterns SBP: Systolic blood pressure; DBP: Diastolic blood pressure; DASH: Dietary Approach to Stop Hypertension; MED: Mediterranean diet.

hypertension across tertiles of dietary pattern adherence. Higher adherence to the DASH and MED dietary patterns was associated with reduced OR of pre-hypertension occurrence by 13% (OR: 0.87; 95% CI: 0.70–0.98; P trend = 0.042) and 16% (OR: 0.84; 95% CI: 0.69–0.97; P trend = 0.035), respectively.

Discussion

Our results showed that adherence to the DASH and MED dietary patterns was inversely associated with the odds for pre-hypertension occurrence after adjustment for all potential confounders. We also found an inverse association between adherence to both diets and SBP, but not DBP.

Table 3 Multivariable-adjusted regression for blood pressure and dietary pattern adherence scores.

	SBP		DBP	
	β (95% CI)	P value	β (95% CI)	P value
DASH diet:				
Model 1	−0.06 (−0.31, −0.04)	0.012	−0.04 (−0.20, 0.01)	0.078
Model 2	−0.05 (−0.24, 0.07)	0.104	−0.01 (−0.13, 0.06)	0.505
Model 3	−0.05 (−0.21, 0.02)	0.082	−0.01 (−0.11, 0.09)	0.794
Model 4	−0.04 (−0.29, −0.01)	0.039	−0.03 (−0.16, 0.03)	0.187
MED diet:				
Model 1	−0.01 (−0.50, 0.33)	0.680	0.03 (−0.14, 0.51)	0.270
Model 2	−0.02 (−0.57, 0.18)	0.314	0.02 (−0.19, 0.41)	0.460
Model 3	−0.03 (−0.61, 0.15)	0.243	0.01 (−0.23, 0.37)	0.656
Model 4	−0.04 (−0.72, −0.02)	0.044	−0.01 (−0.34, 0.25)	0.760

DASH: Dietary approach to stop hypertension; MED: Mediterranean. Model 1: Crude model. Model 2: Adjusted for age and sex. Model 3: Additionally, adjusted for physical activity, education, and energy. Model 4: Additionally, adjusted for body mass index.

Higher adherence to the DASH diet was significantly related to lower SBP and DBP. However, it was not significantly associated with MED diet.

In regards to the DASH diet and in line with our findings, some recent randomized controlled trials (RCTs) revealed that higher adherence to DASH dietary pattern significantly reduced SBP, but not DBP levels in individuals with pre-hypertension and type 2 diabetes [39] and also declined risk of developing hypertension [39,40]. Data from an interventional nonrandomized controlled study similarly showed that adherence to the DASH diet led to a significant reduction in SBP [41]. In another RCT, Juraschek et al. evaluated the effects of low versus high sodium, DASH versus control, and both (low sodium-DASH vs. high sodium-control diets) on SBP and found that the combination of reduced sodium intake and the DASH diet has lowered SBP throughout the range of pre- and stage 1 hypertension [42]. In two large cohort studies, adherence to the DASH dietary pattern was related to lower levels of DBP after 10 years of follow-up [43,44], while another recent longitudinal study associated adherence to the DASH diet with 26% lower risk of developing hypertension [45]. On the contrary to these findings, Divens et al. [46] did not find any significant changes in SBP and DBP in African American women who followed the DASH dietary pattern for one year. Furthermore, the results of the large cohort study Iowa Women's Health Study were in non-concordance with our findings and indicated no association between DASH diet and incidence of hypertension [47]. A systematic review of 17 clinical trials revealed positive effects of DASH diet on BP especially SBP, whereas the response rate varied among the different subgroups of the DASH diet [48]. According to the reports of recent systematic review, the DASH diet seems to be more effective in BP reduction when the individuals are obese or have a higher basal BP [49]. Based on the results of some studies, a comparison of the DASH diet to the typical US diet showed that the former resulted in lower SBP at every analyzed sodium level (low, intermediate, and high) and lowered DBP at intermediate and high levels [50].

The reports on the MED diet are similarly inconclusive. The Greek European Prospective Investigation into Cancer and Nutrition (EPIC) study evaluated the association between the MED diet and BP. In this study, which was conducted among individuals without any history of hypertension, good adherence to the MED diet was inversely associated with both SBP and DBP [51]. Similar health benefits of MED diets on both SBP and DBP were reported by the Florence cohort study [52]. Contrarily, another cohort study on healthy men and women showed that following the MED diet for four years did not lead to any significant changes in SBP or DBP [53]. In addition, results from the multicenter, randomized clinical trial of Prevención con Dieta Mediterránea (PREDIMED) have shown that compared to the low-fat diet, the MED diet had no effects on SBP, but lowered DBP by 1.5 and 0.7 mmHg in the extra virgin olive oil and in the mixed nuts MED diet intervention groups, respectively [54]. In an RCT by Davis et al., adherence to the MED diet in healthy Australians was

Table 4 Multivariable-adjusted odds ratio and 95% confidence intervals for pre-hypertension across tertiles of dietary pattern adherence scores in adults.

	Tertile 1	Tertile 2	Tertile 3	P for trend
DASH diet:				
Model 1	1	1.05 (0.78–1.32)	0.78 (0.58–1.03)	0.051
Model 2	1	1.04 (0.86–1.23)	0.85 (0.61–1.09)	0.206
Model 3	1	1.06 (0.88–1.25)	0.88 (0.69–1.07)	0.334
Model 4	1	0.95 (0.77–1.15)	0.87 (0.70–0.98)	0.042
MED diet:				
Model 1	1	1.14 (0.85–1.53)	0.98 (0.74–1.31)	0.807
Model 2	1	1.09 (0.80–1.50)	0.93 (0.70–1.25)	0.843
Model 3	1	1.10 (0.80–1.50)	0.90 (0.66–1.21)	0.662
Model 4	1	0.99 (0.72–1.37)	0.84 (0.69–0.97)	0.035

DASH: Dietary approach to stop hypertension; MED: Mediterranean. Model 1: Crude model. Model 2: Adjusted for age and sex. Model 3: Additionally, adjusted for physical activity, education, and energy. Model 4: Additionally, adjusted for body mass index.

associated with a significant improvement in SBP at both three- and six-month intervals [55]. In line with our findings, Kesse-Guyot et al. in a cross-sectional study which was conducted among 3232 healthy subjects showed that the MED score was inversely associated with SBP [56]. However, non-significant associations were observed in the Seguimiento Universidad de Navarra (SUN) cohort study after a 6-year follow-up investigating the effects of MED diet on hypertension in healthy individuals [53].

A recent umbrella review of systematic reviews and meta-analyses reported that the DASH dietary pattern was associated with BP improvement which may translate to the CVD risk reduction by 20% [9]. In addition, the strong evidence from the PREDIMED study showed that as the primary prevention of cardiovascular risk in high-risk patients, a MED diet significantly reduced the risk of major cardiovascular events by 30% [57]. Thus, both the DASH and MED dietary patterns may play a major role in first-line BP prevention and therapy as well as CVD prevention.

These contradictory reports in the health effects of the DASH and MED diets might be attributed to the classification, scoring methods, study design, sample size validity of dietary assessment tools, and population studied [58,59]. Both the DASH diet and the MED diet have common features, but also exhibit different sets of components, which contribute to the cardiovascular health through different mechanisms [60]. Both diets are relatively palatable, generally easy to adhere to, and are high in fruit, vegetables, whole grains, nuts, and unsaturated oils, all have been shown to reduce the risk of elevated BP [61,62]. Besides, both diets minimize the consumption of red and processed meat, which is in accordance with dietary recommendations for CVD risk reduction [61]. The DASH diet contains more protein sources including poultry and fish and emphasizes the intake of free- or low-fat dairy products both shown to have hypotensive effects [61], while among the major features of the MED diet are olive oil and nuts which have been shown to have health effects in prevention and control of hypertension [61,63]. In addition, the restricted sodium version of DASH diet had also low sodium [60], which is not a feature of the MED diet.

Previous studies have reported the hypotensive effects of both DASH and MED diets due to their high potassium, calcium, magnesium, and low sodium content [60]. Our finding similarly confirmed that the participants in the highest tertiles of both DASH and MED diets consumed greater amounts of magnesium and calcium and lower amounts of sodium. Elevated sodium intake has been linked with a higher risk for hypertension [64], whereas, as in line with WHO recommendation, low sodium to potassium ratio is the major factor in BP management and global public health [65].

Strengths and limitations

The strengths of the current cross-sectional study include appropriate sample size, simultaneous evaluation of two important dietary patterns related to CVD and its risk factors, and adjusting the results for different confounding variables. The larger body of evidence has evaluated these patterns with hypertension and its lowering BP effects. The novelty of our study is the population included in the analyses. Also, in this work, the use of a semi-quantitative FFQ created for the Iranian population was an appropriate strategy to minimize the issue of the cumulative impact of DASH and Mediterranean diets.

However, our study had some limitations. The design of our study was cross-sectional, and this prohibits inferring a causal link between dietary patterns and BP. Also, using an FFQ for dietary intake evaluation may increase the risk of recall bias. Another limitation was the lack of data on psychological status as a potential effective factor on BP.

Conclusions

We concluded that there is a significant inverse association between adherence to DASH and MED diets and the occurrence of pre-hypertension and lower SBP in non-hypertensive population. Our findings emphasize the relation of these dietary patterns for hypertension prevention and consequently lower CVD risk. Therefore, it can be translated into their reduction effect in clinical outcomes of clinical practice and public health importance in hypertension.

Ethics approval and consent to participate

The study was approved by the Isfahan Cardiovascular Research Institute (WHO collaborative center) ethics committee. Written informed consents were obtained from all of the participants.

Consent for publication

All authors consent to the publication of the manuscript in Nutrition Journal.

Availability of data and materials

The authors confirm that the data supporting the findings of this study are available.

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Authors' contributions

MR, NM, and NG designed the study; NM, NBJ, and MR collected the data; AKH analyzed the data; NM, YM, and NG interpreted the data; NM and MR wrote the first draft; all authors read and confirmed the manuscript.

Declaration of competing interest

We declare that we have no conflict of interest.

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